REMARKS

The Office Action mailed September 29, 2005, has been carefully considered. In response, the application has been amended in a manner that is considered to place it into consideration for allowance. Accordingly, reconsideration and withdrawal of the outstanding Office Action and issuance of a Notice of Allowance are respectfully solicited in view of the foregoing amendments and the following remarks.

The Applicant respectfully submits that the claim amendments overcome the claim objections.

Claims 1, 2, 9, 11, 12, 33, 40, and 42-46 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,377,652 (*Sturm*) in view of U.S. Patent No. 6,456,691 (*Takahashi, et al.*). Claims 3, 4, 10, 17, 20-24, 28, 34, 35, 41, 61-64, 68, 70, and 71 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patent to *Sturm* and *Takahashi, et al.* and further in view of U.S. Patent No. 4,047,029 (Allport). Claims 5-7, 13-16, 18, 19, 25-27, 36-38, 49-58, and 65-67 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patent to *Sturm, Takahashi, et al.*, and *Allport, et al.* in view U.S. Patent No. 6,178,226 (*Hell, et al.*). Claims 8, 29, 39, and 69 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patents to *Sturm* and *Takahashi, et al., Allport, et al.*, and *Hell, et al.* in view of U.S. Patent Application Publication No. 2002/015020(*Yokhin*). Claims 30, 31, 72, and 73 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,442,233 (*Grodzins, et al.*) in view of the patent to *Takahashi, et al.*). Claims 32 and 74 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patents to *Grodzins, et al.* and *Takahashi, et al.* and further in view of U.S. Patent No. 4,152,591 (*Averitt, et al.*). Claims 33, 47, 48, 72, and 75 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Application Publication No.

2002/0141535 (*Torai, et al.*) in view of the patent to *Takahashi, et al.* Claims 49, 59, and 60 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patent to *Torai, et al.* in view of the patents to *Takahahsi, et al.* and *Yokhin*. Claims 76-79 are rejected over U.S. Patent No. 2,798,177 (*Wideroe*) in view of the patent to *Takahashi, et al.* Claims 80-82 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,598,451 (*Ohno, et al.*) in view of the patent to *Takahashi, et al.* Claims 80 and 83 are rejectged under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,280,513 (*Meltzer*) in view of the patent to *Takahashi, et al.* Claims 84 and 85 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patents to *Meltzer* and *Takahashi, et al.* and further in view of U.S. Patent No. 6,252,930 (*MacKenzie*). Claims 86-89 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Application Publication No. 2004/0218714 (Faust) in view of the patents to *Takahsahi, et al.* and *Averitt*. Claim 90 is rejected under 35 U.S.C. § 103(a) as being unpatentable over the patents to Faust, *Takahashi, et al.*, and Averitt and further in view of U.S. Patent No. 5,410,575 (Uhm). Claims 91-93 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patents to Faust, *Takahashi, et al.*, and Averitt and further in view of U.S. Patent No. 5,430,787 (Norton). Claims 91 and 94 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the patents to Faust, *Takahashi, et al.*, and Averitt and further in view of U.S. Patent No. 5,202,932 (*Cambier, et al.*). The grounds for the rejections are set forth on pages 4-23.

The Applicant respectfully submits that the claims as amended overcome the above grounds of rejection. As will be explained below, none of the combinations of references applied in the Office Action would have resulted in, taught, or suggested the present claimed invention.

The use of a carbon nanotube cold cathode x-ray source solves many of the critical problems and deficiencies in x-ray based measurement devices in a manner that would not have been obvious and is not a mere substitution of a carbon nanotube cold cathode device for a conventional heated filament hot cathode x-ray tube.

Useful on-line measurements for industrial and many other applications require stability and accuracy that are very difficult and in most cases not possible to obtain with conventional x-ray tubes. These on-line measurements require absolute measurement of weight, basis weight or thickness in engineering units, such as ounces per square yard, grams per square meter, or mills thickness. The instrument needs to give the same measurement for the same quantity of material over an extended period of time, and after the instrument has been turned on and off, and used in a variety of hostile industrial environments. Any drift or change in the x-ray beam output of the instrument gives an error in the measurement that is almost certainly not acceptable.

Instruments based on conventional x-ray tubes are very unstable, and need to be first "seasoned" by allowing them to run for an extended period of time to break in and stabilize, and then they are typically not turned off from day to day so that the x-ray output remains stable. In evidence of this, they typically have a mechanical safety shutter to block the beam when they are not in use, even though they are electronic devices that could be turned off. This is to keep them turned on and running continually over many days so that the beam is not disturbed.

A most desirable and commercially viable instrument is one that simply uses the scattering of the x-rays, chiefly by Compton scattering, to make the stable measurement of the weight or thickness of the sheet or material being measured.

This is why US 6,442,233 B1 by Grodzins teaches only an "inspection", not a quantitative measurement, using coherent scattering of x-rays by material in a container.

This is why US 6,377,652 B1 by Sturm teaches the measurement of mineral additives, because the mineral additives have a strongly different, much larger and non linear response to x-rays than does the paper or the other low atomic number constituents of the sheet. This difference is capitalized upon to overcome the limitations of the conventional x-ray tube.

US 4,047,029 by Allport teaches a gauge for measuring the thickness or mass per unit area of a sheet using an x-ray beam where continual measurement of both the transmitted and scattered beam are made and their ratio is computed or a beam intensity measurement is made before the beam impinges upon the material and the ratio of this beam intensity to the transmitted and backscattered beam are employed. In all of Allport's teachings, ratios of beams are employed to compensate for material composition changes, and this also compensates for x-ray beam intensity changes, which Allport does not directly address, but is an outcome of his teachings and is essential for his teachings to work.

None of the above teach the use of an x-ray source and a detector being used on a paper, plastic or other low atomic number material to give a suitable measurement of weight, basis weight or thickness, without some other technique or method used in conjunction with them or some other limitation or qualification placed on the measurement, such as an "inspection," a coherent scattering, a shaped spectrum, and so forth. This is because the existing x-ray tubes and sources did not have the essential qualities of stability and reproducibility needed to make measurements to the required specifications to make them useful in practical applications.

US 6,456,691 B2 by Takahashi et. al. teaches the use of a carbon nanotube material as a cold cathode for an x-ray generator and teaches that the voltage of the grid or Wehnelt can be varied to control the field emission of electrons from the carbon nanotube. Takahashi says that the advantages of this are low power, low temperature, no high current cable that carries the

large filament current, no heating and outgassing, sometimes termed seasoning the tube, long lifetime of the cathode and no stringent requirements on the vacuum on the tube.

Very important is that Takahashi does not teach that the control over the carbon nanotube field emission can be used to stabilize the x-ray output beam or that this control can be made to be very rapid, at radio frequencies if desired, so that phase locked techniques can be employed if desired to further stabilize the measurement without sacrificing response time of the measurement. Furthermore, Takahashi does not teach the use of such a carbon nanotube cold cathode x-ray tube in any type of measuring device, presumably because these advantages were not obvious or not known to be so important to the operation of these devices.

US 6,178,226 B1 by Hell et. al. teaches methods of controlling an electron current in an x-ray tube. This is done while the hot filament is still heated and emitting electrons by changing a voltage that blocks the electrons or controls the path of the electrons so that the electrons do not strike the anode target and produce x-rays. The limitation of this procedure is that the drifts inherent in the heated filament hot cathode are not compensated by this form of control. It is merely a way to deflect the beam or otherwise inhibit the x-ray output, but does nothing to stabilize the beam or add accuracy to a measurement that would result from using this technique in an instrument.

The applied prior art will now be reviewed in greater detail to highlight a persistent problem to which the present claimed invention provides a solution.

Sturm is directed specifically to the determination of mineral components in a sample by means of evaluating the signal obtained at three different detectors where the x-rays impinging on each detector are first filtered by an x-ray energy discriminating filter specific to each detector. In this way, each of the three detectors is mainly responsive to only one primary band

of x-ray energy. Given that minerals will contain elements of higher atomic number than the organic cellulose material of the sheet, customarily paper, these higher atomic number elements will have markedly differently x-ray absorption properties as a function of the energy of the x-ray. By processing these three separate detector's outputs that are responsive to only one unique band of x-ray energy, the mineral content can be determined in a manner that factors out other things that may be in common to each detector, such as x-ray tube output intensity drifts.

Therefore, the teachings of Sturm et. al., even if they specifically do not state as much, do indeed depend upon a method that eliminates the output drift of the x-ray tube. However, that method is considerably more complicated and less practical than that offered by the present invention.

The teachings in Allport rely on a manner of making a measurement that utilizes multiple detectors with the express purpose of combining their outputs to form ratios that have the effect of eliminating common influences, such as x-ray tube drift. Allport teaches that the detector that is positioned on the opposite side of the sheet from the x-ray source, which is responsive to absorbed x-rays, can be taken in a ratio with a detector positioned on the same side of the web as the x-ray source that sees only backscattered x-rays. Each of these two detector's signal is directly related to the x-ray tube's output, so this becomes a common factor that is eliminated by taking the ratio of these two signals. Even though Allport does not specifically state that this is the intent of his teachings, it is the undisputable consequence that makes his teachings work. An alternate approach taught by Allport is to first measure the intensity of the x-ray beam before the x-ray beam impinges upon the sheet and then take the ratio of this x-ray beam strength measurement to each of the transmitted and backscattered detector's signal. This more

specifically is directed to eliminating the problems associated with the drift of the x-ray tube. However, the present claimed invention offers a simpler and better solution.

The teachings of Grodzins rely, somewhat analogous to Sturm above, on measuring the energy spectrum of the x-rays that have been coherently scattered by an object within a volume or enclosure for the purpose of determining the presence of material or objects that generate different x-ray energy spectra from the base or reference spectra of material within the enclosure. This is not a weight or thickness measurement technique and is very crude in this regard, as the object only needs to be big enough to register with the spatial resolution of the position scanning apparatus that this technique relies upon and beyond that only the object's presence or lack of presence is indicated by the instrument. This is therefore termed an inspection device and not a mass or weight measurement device. The spectral differences are used to make the determination as to whether or not an object of interest is present and the difference in the received x-rays as a function of the x-ray energy is independent from the intensity of the x-ray tube's output intensity.

Thus, there is a persistent and unmet need in the art for a simple, reliable solution to the problem of drift. The present claimed invention offers such a solution.

For many years in the industrial measurement and gauging industry, radioisotope radiation sources were employed because of their short term stability, which is statistically given by their radioactive decay rate. This rate is known for every radioisotope employed and in some cases where the lifetime, more accurately termed half-life, was short, the radiation output with time can even be precisely computed and corrected for based on this precise factor. Even though radioisotope based gauges suffered from perceived fear of contamination, exposure and other safety issues that have become very critical in recent years, the radioisotope based gauge has

continued to be employed mainly because of it stable and predictable output of radiation that can be reliably used in measuring instruments that needed accurate, reproducible and dependable results. Instruments that employed x-rays were found only in applications that fit the various scenarios described in part by the teachings in the above patents, where the x-ray output intensity fluctuations and other deficiencies of the x-ray tube could be tolerated.

The instrument and methods taught by this invention show how a new type of x-ray source can be combined with a single detector in a manner similar to how radioisotope based instruments have operated for many years. This new instrument can make quantitative measurements of weight, mass and thickness of even low atomic number materials including plastic, paper, organic materials and so forth. Because this new instrument could operate like a radioisotope based instrument, we have used the term "synthetic radiation source" to underscore this important distinction.

All of the teachings in the above patents that employ x-ray sources completely rely upon methods that factor out the instability of the x–ray source's output, as explained in the details given above. These instabilities are indistinguishable from actual changes in the mass, weight or thickness of the sheet or material being measured, so fatal errors in measurement occur when these instabilities are present.

The present claimed invention uses the fact that the stability of a carbon nanotube based cold cathode x-ray source can be made quite stable by stably controlling the voltage that generates the field emission of electrons from the carbon nanotubes and that this is of paramount importance for the instrument. The teachings of US 6,456,691 B2 by Takahashi do not teach this. Takahashi teaches that in order to achieve stability in the x-ray output, the carbon nanotube cold cathode should emit electrons that then heat a second element by electron bombardment and

this second element becomes a hot electron emitting cathode. It is the electrons from this second element that are accelerated to impinge upon the target and generate x-rays. This is not what my patent discloses and has the drawback that a hot element is once again used to generate the electrons with the only advantage that no high current conductor that supplies the heated filament is used in the cable assembly to the x-ray tube.

In order to achieve enhanced stability with a carbon nanotube cold cathode and compensate out the effects of leakage current and so forth, the present claimed invention, in at least some of the claims, teaches the technique of rapid modulation of the voltage on the carbon nanotube cold cathode. This technique is not taught by Takahashi.

The other references of record do not overcome the deficiencies of the references described above.

Therefore, the Applicant respectfully submits that the invention fills a long felt need in the art and that no combination of the applied references would have resulted in, taught, motivated, or even vaguely suggested the solution to that need provided by the present claimed invention.

For the reasons set forth above, the Applicant respectfully submits that the application as amended is in condition for allowance. Notice of such allowance is respectfully solicited.

In the event there are any questions relating to this Amendment or to the application in general, it would be appreciated if the Examiner would telephone the undersigned attorney concerning such questions so that prosecution of this application may be expedited.

Please charge any deficiency in fees, or credit any overpayment thereof, to the account of Blank Rome, LLP, Deposit Account No. 23-2185 (000049-00110). In the event that a Petition for Extension of Time is required to render the present Amendment timely and either does not

accompany the present Amendment or does not suffice to render the present Amendment timely, the Applicant respectfully petitions under 37 C.F.R. § 1.136(a) for an extension of time for as many months as are required to render the present Amendment timely. Any fee due is authorized above.

Respectfully submitted,

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